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Review Article

The Orthodontic-Restorative Interface: A Narrative Review of Pre-Prosthetic Space Management, Implant Site Development and Multidisciplinary Treatment Planning

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Abstract

Background: Adults seeking complex dental rehabilitation rarely present with a single problem. Tooth loss, malocclusion, periodontal disease and failing restorations tend to arrive together, yet the orthodontic component of these cases is still frequently overlooked or left to the end of treatment planning. A framework that integrates space management, implant site development and interdisciplinary sequencing into a coherent clinical approach remains largely absent from the literature.

Objective: To review current evidence on pre-prosthetic orthodontic treatment, implant site development, diagnostic planning and treatment sequencing in complex adult rehabilitation and to offer clinicians a practical, structured reference for interdisciplinary decision-making.

Methods: A narrative review was conducted using PubMed, Scopus and Google Scholar. Studies were selected across six thematic areas: orthodontic-restorative integration, forced eruption for implant site development, molar uprighting, space management in hypodontia and lateral incisor agenesis cases, digital planning workflows and retention protocols.

Results: When treatment planning starts from the prosthetic endpoint and works backward, restorative outcomes are more predictable. Orthodontic forced eruption can generate meaningful bone and soft tissue gains before implant placement, but results vary, retention interval, force magnitude and individual biology all matter and supplementary grafting is still needed in a meaningful number of cases. Molar uprighting improves both the geometry of posterior implant sites and the periodontal status of the uprighted tooth. For maxillary lateral incisor agenesis, space closure with canine substitution shows favorable esthetic and periodontal results compared to implant replacement in well-selected patients, though neither approach is superior across all presentations. Digital planning tools improve communication between specialists but cannot account for how individual patients actually respond biologically. Retention needs to be actively managed, not just prescribed, with protocols adapted to each patient's clinical situation.

Conclusion: Orthodontics is not an add-on to complex rehabilitation; it shapes whether the restorative phases that follow are even feasible. The evidence supports this, but biological variability, inconsistent protocols and limited long-term data mean

clinicians are still relying heavily on judgment. Until better-defined criteria for restorative readiness emerge from prospective research, individualized planning and genuine interdisciplinary communication remain the most reliable tools available.

Keywords: Interdisciplinary Dentistry; Pre-Prosthetic Orthodontics; Implant Site Development; Forced Eruption; Space Management; Lateral Incisor Agenesis; Molar Uprighting; Digital Workflow; Retention; Complex Rehabilitation

Introduction to the Convergence of Orthodontics and Restorative Dentistry in Complex Rehabilitations

Adult patients seeking dental rehabilitation today rarely present with isolated problems. Tooth loss, periodontal disease, occlusal discrepancies and failing restorations frequently coexist and addressing any one of them without considering the others risks compromising the overall outcome. Epidemiological studies consistently report that a substantial majority of adults exhibit some form of malocclusion, yet adults have historically been underrepresented in orthodontic practice; accounting for as few as 15% of orthodontic patients in the late 1990s, though current estimates suggest this proportion has grown considerably, with adults now constituting roughly one-third of the orthodontic patient population [1-3]. This gap reflects how often the orthodontic component of complex rehabilitations goes unrecognized or is deferred until late in treatment [2,3].

This reality has made interdisciplinary treatment planning not a preference, but a clinical necessity. Managing these patients within a single specialty; placing implants without first correcting space deficiencies or restoring teeth without addressing the underlying occlusion, consistently produces outcomes that are harder to maintain and more likely to fail over time [3]. Orthodontics, prosthodontics, periodontics and implantology must now function as a coordinated system, with each phase planned in anticipation of the next [4]. The question is no longer whether these disciplines should work together, but how to sequence and integrate them effectively [5].

A central challenge in this integration is pre-prosthetic space management and implant site development. After tooth loss, alveolar bone resorbs progressively, narrowing the window for predictable implant placement without augmentation [5]. Orthodontic forced eruption has gained clinical traction as a minimally invasive method to regenerate hard and soft tissue architecture before implant placement, particularly in the anterior maxilla where esthetic demands are highest [4]. Surgical alternatives; guided bone regeneration, ridge augmentation and socket grafting, remain essential in cases with more significant bone deficiency, but each carries its own indications, limitations and impact on treatment timelines [5,6]. Selecting the right strategy requires early diagnosis and a clear understanding of the final prosthetic objective [6].

That prosthetic objective must drive every decision made upstream. Implant axis, emergence profile, crown proportions and occlusal contacts are all directly influenced by how teeth are positioned orthodontically before surgery and restoration begin. A reverse planning approach; starting from the final restoration and working backward through the surgical and orthodontic phases; is now considered the standard of care in complex rehabilitations and evolving digital workflows have made this increasingly feasible in routine practice, though adoption and supporting evidence remain uneven across settings [4-6]. When this sequence is followed, orthodontic treatment functions as the foundation upon which predictable restorative outcomes are built. When it is bypassed or treated as secondary, the result is clinical compromise that is difficult and expensive to correct [5,6].

Despite this, a unified clinical framework that addresses space management, implant site development and interdisciplinary sequencing together; rather than as separate topics, remains underrepresented in the literature [5]. Most existing reviews focus on individual techniques or specialty-specific perspectives, leaving clinicians without clear guidance on how to integrate these elements into a coherent treatment plan [7]. This narrative review aims to address that gap by synthesizing current evidence on pre-prosthetic orthodontic treatment, implant site development strategies and multidisciplinary planning principles, with the goal of offering clinicians a practical and structured approach to complex adult dental rehabilitation.

Diagnostic Framework and Treatment Planning in the Interdisciplinary Patient

The interdisciplinary management of complex oral rehabilitations has progressively evolved toward a prosthetically driven diagnostic paradigm, in which clinical success is increasingly determined by the integration of diagnostic synthesis, digital simulation and structured interdisciplinary communication. Contemporary evidence suggests that predictable outcomes depend less on isolated specialty performance and more on establishing a unified diagnostic framework prior to clinical intervention [8,9].

Within this paradigm, the diagnostic workflow can be conceptually structured into four interdependent phases: (1) diagnostic acquisition, (2) interdisciplinary synthesis, (3) prosthetic simulation and (4) treatment execution guided by restorative endpoints. This sequential yet dynamic model ensures that orthodontic tooth movement remains continuously aligned with a prosthetically driven objective rather than isolated occlusal correction [8,9].

Diagnostic Acquisition as a Predictive Foundation

Pre-treatment records including standardized photography, intraoral digital scans, mounted casts and cephalometric analysis, constitute the diagnostic foundation of interdisciplinary planning. However, their role extends beyond documentation toward predictive treatment modeling. In interdisciplinary contexts, cephalometric analysis should be interpreted as a planning instrument that informs incisal positioning, restorative space allocation and occlusal harmony rather than solely skeletal relationships [8]. Despite this, a persistent limitation in clinical practice remains the fragmentation of diagnostic interpretation across specialties, often referred to as the "silo effect", which reduces the translational value of diagnostic data and weakens restorative alignment. This reinforces the necessity of early diagnostic integration, where orthodontic and restorative objectives are defined concurrently rather than sequentially [9].

Occlusion as a Restorative Constraint System

Occlusal analysis has shifted from a functional orthodontic evaluation to a structural determinant of restorative feasibility. When occlusion is conceptualized as a biomechanical constraint system, it governs permissible tooth movement trajectories and establishes the envelope within which prosthetic design must operate.[9] When occlusal analysis is performed without restorative foresight, orthodontic alignment may be achieved at the expense of prosthetic requirements such as crown proportion, emergence profile or vertical dimension stability; a disconnect that remains one of the most common sources of interdisciplinary discrepancy in complex rehabilitation cases [8,9]. Occlusion should therefore be interpreted as a shared diagnostic interface between orthodontic mechanics and prosthetic design principles.

Prosthetic Simulation: Wax-ups and Digital Smile Design

The transition from diagnosis to execution is mediated through diagnostic wax-ups and Digital Smile Design (DSD), which function as prosthetic translation tools. Wax-ups provide a physical or digital representation of the restorative endpoint, allowing definition of critical parameters such as tooth proportion, occlusal vertical dimension and anterior guidance prior to orthodontic intervention [10]. DSD enhances interdisciplinary communication by establishing a shared visual framework among clinicians and laboratory technicians [10,11].

However, a critical limitation must be acknowledged: digital idealization may introduce perceptual bias, where esthetic simulation can unintentionally override biological constraints such as periodontal architecture, soft tissue behavior and functional adaptation. These tools should therefore be interpreted as decision-support systems rather than deterministic planning outputs [9].

Three-Dimensional Virtual Planning and Predictive Limitations

The introduction of three-dimensional virtual treatment planning has significantly improved interdisciplinary predictability, allowing clinicians to test orthodontic movements against restorative objectives prior to treatment initiation, thereby reducing therapeutic uncertainty and improving sequencing [11]. However, current digital systems remain limited in their ability to accurately replicate long-term biological responses, particularly in soft tissue adaptation, periodontal remodeling and neuromuscular function [9,11]. This limitation reinforces a central principle of modern interdisciplinary dentistry: digital precision does not equate to biological predictability.

Structured Communication Protocols

Interdisciplinary communication represents a core determinant of treatment success and should be regarded as a structured clinical protocol rather than an informal exchange [8]. A standardized framework should include a pre-treatment interdisciplinary consensus meeting, a restorative-driven orthodontic prescription, a shared digital planning platform integrating DSD and three-dimensional tools and phase-based reassessment checkpoints throughout treatment progression [8,9]. Without this structured framework, even advanced digital workflows risk fragmentation and reduced clinical transferability.

Ultimately, successful interdisciplinary treatment is defined not by isolated technical excellence but by the coherent integration

of diagnostic reasoning, prosthetic vision and collaborative execution [8,9].

Pre-Prosthetic Space Management: From Biomechanical Principles to Implant Site Readiness in the Partially Edentulous Patient

Space Creation, Maintenance and Redistribution

Pre-prosthetic space management, whether involving the creation, maintenance or redistribution of space for missing or compromised teeth, remains one of the most demanding challenges in contemporary interdisciplinary orthodontics. Its complexity lies not only in the technical execution of tooth movement but in the need to satisfy biological, functional and esthetic requirements simultaneously in a patient population that is often periodontally compromised and skeletally mature [12-14].

An effective strategy begins with early and precise diagnosis and must be built around a clearly defined prosthetic endpoint. Beyond the mesiodistal dimension of the space, the clinician must account for its full three-dimensional configuration, vertical bone height, buccolingual width, soft tissue volume, root parallelism of adjacent teeth, occlusal relationships and facial esthetic proportions. Each of these factors influences not only whether an implant can be placed but whether it can be maintained and restored predictably over time.[12,13] When managed correctly from the outset, orthodontic space management produces sites with stable gingival architecture, adequate bone volume and properly oriented roots precisely the conditions that make downstream surgical and prosthetic phases more straightforward.

Dimensional Requirements and Biomechanical Control

When planning a pre-prosthetic site, the literature supports targeting specific horizontal and vertical dimensions for both hard and soft tissue, while simultaneously controlling root parallelism, tipping, abutment height, gingival contour and emergence profile [15]. These parameters are interdependent and failure to manage any one of them tends to compromise the others.

Achieving adequate root divergence adjacent to an edentulous space requires deliberate control of torque, tipping and bodily tooth movement throughout the orthodontic phase. Unwanted root inclinations are among the most common biomechanical errors in pre-prosthetic cases and can render implant placement impossible without prior corrective treatment. When clinical assessment alone is insufficient, cone-beam computed tomography provides an indispensable three-dimensional reference for evaluating cortical plate integrity and bone thickness at anatomically critical points before and during treatment [3]

Maxillary Lateral Incisor Agenesis: Space Closure Versus Implant Site Development

Maxillary lateral incisor agenesis is among the most prevalent dental anomalies encountered in interdisciplinary practice, with a well-documented predominance in females.[12] When the treatment team and patient opt for orthodontic space closure over prosthetic replacement, the evidence supports this approach across multiple outcome domains: gingival zenith position and morphology tend to remain within accepted esthetic parameters, periodontal outcomes are favorable, implant-related complications are eliminated entirely, skeletal maturity is not a limiting factor and long-term cost-effectiveness is generally superior [12,13].

The biomechanics of canine substitution are well defined but technically demanding. Mesialization of the canine must be accompanied by precise control of root position, torque and selective vertical movement, all while building toward anterior guidance, stable posterior occlusion and gingival symmetry. The most critical and difficult step is modifying the canine's root torque to approximate the inclination typical of a lateral incisor. Palatal movement of the root apex reduces alveolar ridge prominence, improves the interproximal contact zone with the central incisor and decreases axial load on the lower anterior dentition. The evidence consistently supports the use of rigid rectangular archwires with negative torque prescription in the canine bracket to achieve this movement reliably [12,13].

Cases of unilateral agenesis; particularly those combined with a contralateral peg-shaped or microdontic lateral incisor, require an additional layer of decision-making, as the choice between space opening and space closure carries distinct restorative and esthetic consequences depending on the morphology and position of the affected teeth [14].

Implant Site Development Through Orthodontic Mechanics

Forced Eruption and Dentoalveolar Remodeling

Among the orthodontic strategies available for implant site development, forced eruption occupies a distinctive position; one grounded in the body's own remodeling biology rather than in surgical substitution for it. By applying a controlled extrusive force to a tooth that is structurally compromised or planned for extraction, the clinician stimulates the coronal migration of the attachment apparatus, carrying alveolar bone and soft tissue coronally in the process. The result is a localized gain in ridge height, keratinized tissue volume and gingival architecture that would otherwise require surgical augmentation procedures to achieve [4,5].

What makes this approach particularly valuable in the context of implant planning is its mechanism: the dentoalveolar complex responds to orthodontic loading by depositing new bone at the base of the socket as the tooth erupts, while the gingival tissues follow passively and remodel their contour in response.[16] When performed gradually and with an adequate stabilization interval before extraction, the hard and soft tissue gains achieved through forced eruption are generally stable and well-integrated, though it must be acknowledged that the precise timing of bone maturation remains incompletely defined in the literature and outcomes are sensitive to force magnitude, eruption rate and patient-specific biological factors [17].

The anterior maxilla is where this technique finds its most frequent and clinically consequential application. Esthetic demands in this region are high and even modest deficiencies in ridge height or soft tissue contour can produce restoration outcomes that are difficult to correct after the fact. Forced eruption offers a means of building a more favorable implant site before the tooth is ever extracted, arriving at surgery with a ridge that is closer to the ideal dimensions required for predictable implant placement and natural-looking emergence profiles [4,5].

Molar Uprighting for Posterior Implant Site Preparation

The posterior implant site presents a distinct but equally important set of challenges [17]. When a first molar is lost and the adjacent second molar drifts mesially over time, the resulting angulation creates a site that is unsuitable for standard implant placement in multiple ways: the tipped root encroaches on the mesiodistal space, the alveolar bone remodels asymmetrically in response to the altered load distribution and critically angular bone loss and increased probing depths on the mesial surface of the inclined molar frequently accompany prolonged tipping, adding a periodontal dimension to what begins as a purely spatial problem [18].

Orthodontic uprighting of tipped molars addresses these issues directly. By applying a distalizing and torquing force to the mesially inclined tooth, the clinician restores root parallelism, redistributes the interradicular space and allows the alveolar bone to remodel toward a configuration more favorable for implant placement. In many cases, uprighting alone is sufficient to convert a previously inadequate implant site into one that can accept a standard implant without supplementary grafting and to simultaneously improve the periodontal status of the uprighted tooth in the process [18,19].

Temporary skeletal anchorage devices have considerably expanded the biomechanical options available for molar uprighting, allowing the clinician to generate the necessary moments without relying on reciprocal forces transmitted to anterior teeth, a particularly important consideration in partially edentulous patients where the number of available anchorage units may already be limited [18,19].

Orthodontic Extrusion as an Alternative or Adjunct to Surgical Augmentation

The decision between orthodontic extrusion and surgical augmentation for implant site development requires honest appraisal of the biological potential of the tooth being extruded, the severity of the tissue deficit and the clinical demands of the final restoration. In practical terms, extrusion is most appropriate when a tooth with adequate root length and a reasonably intact periodontium is present in a site requiring coronal bone and tissue gain. Surgical augmentation, guided bone regeneration, ridge splitting or block grafting; becomes necessary when no suitable tooth is available for extrusion, when bone deficiency exceeds what orthodontic mechanics can address or when the treatment timeline cannot accommodate the gradual pace that extrusion requires [5,6].

In practice, these two approaches are not always mutually exclusive. Forced eruption can be used to maximize the biological

potential of a compromised site before extraction, reducing the volume of augmentation required at the time of surgery and potentially simplifying the surgical phase considerably. The existing systematic review evidence indicates that both orthodontic extrusion and regenerative surgery can produce satisfying esthetic and functional outcomes when appropriately indicated; but that the orthodontic approach has the advantage of simultaneously enhancing both hard and soft tissue, whereas not all surgical techniques reliably improve soft tissue volume as well [5]. This adjunctive role is particularly well suited to the anterior maxilla and it demands close coordination between the orthodontist and surgeon from the earliest stages of treatment planning, as the timing of extraction, the stabilization period and the sequencing of implant placement all interact in ways that can either compound or undermine the tissue gains achieved orthodontically [4,5].

Clinical Outcomes and Limitations

The clinical evidence supporting orthodontic extrusion for implant site development is encouraging, but it comes with important caveats that must be understood before committing to this approach. The gains in hard and soft tissue volume documented in the literature are real and clinically meaningful, particularly in the anterior maxilla, but they are technique-sensitive, time-dependent and subject to individual biological variability that must be accounted for in treatment planning [4,5].

Retention following extrusion is non-negotiable. If the extruded tooth is extracted before the newly deposited bone has had adequate time to consolidate, the tissue gains risk of partial or full relapse. The retention period reported across studies varies considerably; from as little as six to twelve weeks in some protocols to three to six months in others; reflecting genuine uncertainty in the literature about the minimum stabilization interval required for adequate bone maturation [4,17]. Histomorphometric evidence confirms that newly formed bone following orthodontic extrusion still contains significant proportions of immature woven bone at one to one-and-a-half months of stabilization, suggesting that shorter retention intervals carry a real biological risk.[16] Until the evidence on this point matures, clinicians should err toward longer stabilization intervals and use radiographic assessment to guide the decision.

Patient selection is equally decisive. Teeth with severely resorbed roots, active periapical pathology or insufficient remaining root length to sustain extrusive forces without progressive mobility are poor candidates and attempting extrusion in these situations risks accelerating the need for extraction rather than improving the site [4]. Similarly, adequate plaque control and resolution of active periodontal disease are prerequisites, not afterthoughts, proceeding without them undermines the biological response on which the entire technique depends [4]. When these selection criteria are respected and the technique is applied to appropriately chosen cases, orthodontic extrusion remains one of the most biologically sound and minimally invasive tools available for implant site development in the partially edentulous patient [5,6].

Timing, Sequencing and Retention Considerations in Combined Treatment

The integration of orthodontic and restorative treatment depends not only on accurate diagnosis and space management but on getting the timing and sequencing of each phase right. The handoff from orthodontic to restorative care is a genuinely delicate moment in any interdisciplinary rehabilitation, one where premature decisions or poor coordination between teams can quietly undermine outcomes that took months to build. In complex adult cases, this transition demands a level of active communication that goes beyond simply notifying the restorative clinician that appliances have been removed [18].

Deciding when to move into the restorative phase involves more than checking that teeth look aligned. Current evidence is clear that orthodontic treatment should be considered complete only when tooth positions reflect the intended prosthetic outcome; adequate space distribution, acceptable root parallelism and a stable occlusal scheme that the restorative clinician can actually work with. When planning is genuinely driven by the final restoration, implant placement and prosthetic procedures can proceed without the kind of geometric or biological compromises that are so difficult to recover from later. The sequencing of orthodontic, periodontal and surgical interventions must also be deliberate: poorly timed decisions, such as initiating regenerative surgery in the presence of active orthodontic forces or placing implants before adequate bone consolidation; can negatively affect tissue healing and compromise long-term stability in ways that are not always immediately apparent [19].

Biological stability must be established before definitive restorative procedures begin. After orthodontic tooth movement, both bone and soft tissue undergo a remodeling phase that needs to be respected; not rushed through. Bone continues to remodel even after active treatment ends and placing implants too soon into a site that has not fully consolidated can interfere with

osseointegration in ways that are entirely preventable. Soft tissue stability is equally important, particularly in the esthetic zone, where gingival contours and symmetry are sensitive to the timing of provisionalization and definitive restoration. Management of mucogingival tissues and attention to individual tissue biotype during this window are meaningful factors in reducing the risk of recession and asymmetry that can appear months after what seemed like a well-executed restoration [20].

Occlusal stability is another prerequisite before definitive work begins. The period immediately following orthodontic treatment allows for occlusal settling, during which minor contacts refine themselves into a more balanced functional relationship. Although post-orthodontic occlusal adjustment has traditionally been considered a useful tool, current evidence does not support it as a meaningful contributor to long-term stability; which places even greater responsibility on the finishing phase of orthodontic treatment to establish proper occlusion before appliances come off.[21] Occlusion then becomes a central concern in the restorative phase itself: unfavorable force distribution across implant-supported prostheses is one of the more reliable pathways to mechanical failure and this risk is substantially higher when the occlusal foundation was not carefully established during treatment [21].

Retention during the transition phase is not optional and the evidence supports treating it as its own phase of care rather than an afterthought. Teeth tend to relapse; particularly in the first months after appliance removal; due to continued periodontal remodeling and neuromuscular influences that persist well beyond the end of active treatment. Fixed and removable retainers are the standard tools for maintaining alignment and preserving prosthetic spaces and in cases where implant placement is planned, retainers can be modified to incorporate pontics or provisional elements that maintain both space and esthetics during the waiting period. That said, no retention protocol can fully eliminate movement. Outcomes are influenced by appliance design, bonding quality and patient compliance and the evidence is frank on this point, failure rates for fixed retainers are not trivial and depend on multiple interacting variables that are often outside the clinician's direct control [22]. Retention protocols therefore need to be individualized, explained to the patient clearly and monitored on a schedule rather than left to chance.

Clear interdisciplinary communication ties all of this together. The handoff between the orthodontic and restorative teams should be built on a shared understanding of treatment objectives, expected timing and what each phase is meant to deliver to the next. Digital planning tools have meaningfully improved this exchange by allowing clinicians to visualize sequences, model outcomes and coordinate interventions before they are irreversible. In the end, the difference between a well-sequenced rehabilitation and a difficult one often comes down not to technical skill, both teams may be excellent individually, but, to whether they were genuinely working toward the same endpoint from the start [18].

Conclusion: Synthesis of Current Evidence Supporting an Integrated Orthodontic-Restorative Approach

The evidence reviewed across this paper positions the orthodontic–restorative interface not as an optional refinement of complex rehabilitation, but as one of its structural pillars. When treatment is genuinely organized around a prosthetic endpoint, with orthodontics understood as a means of preparing biological and spatial conditions rather than simply aligning teeth, the downstream phases of surgery, implant placement and restoration become considerably more predictable. A reverse planning approach, in which the final restoration defines the orthodontic objectives rather than follows them, has emerged as the organizing principle of contemporary interdisciplinary practice and is now supported by evidence across multiple clinical contexts [2,23,24].

Orthodontic forced eruption and controlled tooth movement remain among the most biologically rational strategies available for implant site development. Their advantage lies in leveraging the body's own remodeling capacity to produce hard and soft tissue gains that are genuinely integrated rather than grafted. However, the evidence is not unconditional; outcomes vary with force magnitude, eruption rate, retention interval and patient-specific biological response and a meaningful proportion of cases still require supplementary surgical augmentation even after well-executed orthodontic protocols [4,5,15]. These limitations do not undermine the technique's value, but they do underscore that it must be applied with clear patient selection criteria and realistic expectations about what orthodontic mechanics can and cannot accomplish biologically.

Treatment sequencing emerges across the literature as genuinely consequential. The coordination of orthodontic, periodontal and surgical phases requires deliberate planning rather than sequential handoffs between independent specialists and the evidence is clear that periodontal health must be established and stabilized before orthodontic forces are applied [19,25]. Bone

continues to remodel after active treatment ends and implants placed before adequate consolidation carry a preventable biological risk [16]. The periodontal phenotype of the individual patient; including soft tissue biotype and bone morphotype, adds a further layer of variability that influences how tissues respond to orthodontic loading, how gingival architecture adapts around implants and what kind of augmentation may be needed before or during the restorative phase [26]. Until quantitative thresholds for restorative readiness are more consistently defined across study populations, clinical judgment and individualized assessment will remain the primary decision-making tools at this juncture.

Digital planning systems have meaningfully improved communication between disciplines and enhanced the visualization of treatment objectives [9,11]. Their limitation is equally real: these tools cannot incorporate inter-patient variability in bone remodeling, periodontal adaptation or soft tissue behavior [24]. High geometric resolution is not the same as biological predictability and the risk of over-relying on digital simulations at the expense of clinical interpretation is present enough to warrant explicit acknowledgment in practice. Contemporary digital workflows function best when they are understood as decision-support instruments that formalize the prosthetic objective, not as substitutes for the biological reasoning that must underpin every phase of treatment [2,24].

In cases of maxillary lateral incisor agenesis, the literature supports both space closure and implant-based rehabilitation as clinically sound approaches, but neither has established clear superiority across all patient profiles [12-14]. Outcomes depend primarily on individual anatomical conditions, periodontal phenotype, functional requirements and patient preferences rather than on any inherent advantage of one approach over the other. This reinforces a broader conclusion from the reviewed evidence: individualized treatment planning, guided by a thorough understanding of the patient's biological context, consistently outperforms rigid protocol selection [2,23].

Gaps and Clinical Recommendations

Several important gaps remain. Long-term prospective data on the stability of orthodontically developed implant sites are scarce and no consensus exists on the optimal interval between forced eruption completion and implant placement.[4,16] Standardized outcome measures for interdisciplinary rehabilitations; covering hard and soft tissue stability, prosthetic longevity, periodontal health and patient-reported outcomes over adequate follow-up periods; remain inconsistently applied across the literature, which limits meaningful comparison between studies and across disciplines [19,25]. Case selection criteria vary considerably and the field continues to rely more on clinical consensus than on high-level prospective evidence [23].

For practitioners, the implications of the reviewed evidence are reasonably direct: begin treatment planning from the prosthetic endpoint, involve all relevant specialties before treatment starts rather than during it, respect biological stabilization periods before implant placement or definitive restoration, use digital tools as decision support rather than biological surrogates and treat retention as an active monitored phase of care rather than a passive interval [22,24]. Future research should prioritize prospective interdisciplinary trials with predefined, standardized outcome measures and follow-up periods adequate to detect late biological changes; particularly regarding bone maturity thresholds, soft tissue stability and the long-term behavior of implants placed in orthodontically developed sites [5,25,26].

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Data Availability Statement

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Ethical Statement

The project did not meet the definition of human subject research under the purview of the IRB according to federal regulations and therefore was exempt.

Informed Consent Statement
Not Applicable.

Authors' Contributions
All authors contributed equally to this paper.

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